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(54) **AMINO ACID CONJUGATE**  
**AMINOSÄUREN KONJUGATEN**  
**CONJUGAT AMINOACIDE**

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- **ANNE BAKER ET AL.: 'An Improved Strategy for the Stereoselective Synthesis of Glycosides Using Glycosidases as Catalysts' TETRAHEDRON ASYMMETRY vol. 5, no. 12, 1994, pages 2517 - 2522**
- **ENZYME MICROB. TECHNOL. vol. 13, October 1991, pages 781-787; JOHANSSON, E. ET AL.: "Enzymatic synthesis of monosaccharide-amino acid conjugates"**

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**EP 0 779 932 B1**

## Description

[0001] The present invention describes a new method to produce O-glycosylated amino acids, O-glycosylated peptides or derivatives of these. In a further aspect the present invention relates to products produced by the above method as well as uses of the resulting products.

[0002] Glycoconjugates contain oligosaccharide chains with up to twenty monosaccharide units and several sequences have been shown to have biological activity e.g. in the binding to different cells, pathogens, toxins, antibodies or other proteins on cell surfaces, in cancer metastasis, in inflammation processes (for example selectin-carbohydrate interactions), binding of white blood cells to the blood vessel wall, as a modifier of the activity, stability and biological activity of proteins, and as immunogenic substances which have potential for vaccination against different diseases. An extensive literature has been developed during the last few years in this field and there are several review articles on this type of biology, glycobiology, e.g. in Annual Review of Biochemistry and in Current Opinion in Structural Biology (see for example volume 3, 1993).

[0003] One type of glycoconjugate, the glycoproteins, contain carbohydrate-peptide sequences in which the carbohydrate unit is bound to the peptide or protein chain via mainly three different types of linkages, the O-glycosidic linkage represented by GalNAc $\alpha$ -OSer and GalNAc $\alpha$ -OThr, that is the linkage between N-acetyl-D-galactosamine and the hydroxyl group on a L-serine or a L-threonine residue in the peptide of protein chain (several such linkages can be found in a peptide or protein chain depending on the number of serine or threonine units in the molecule), the N-glycosidic linkage between N-acetyl-D-glucosamine and the amide function in asparagine, GlcNAc $\beta$ -N-Asn, and the O-glycosidic linkage between galactose or xylose and different hydroxyl group containing amino acids. Recently, also the  $\beta$ -O-glycosidic linkage between N-acetyl-D-glucosamine and the hydroxyl group on serine or threonine, abbreviated GlcNAc $\beta$ -OSer and GlcNAc $\beta$ -OThr, respectively, has been of increased interest, e.g. because of its suggested importance in the DNA-replication in the nucleus of eucaryotic cells.

[0004] These types of linkage are of interest to produce by synthetic methods for fundamental studies and for synthesis of biologically or pharmaceutically active fragments of glycoproteins, for instance for use as vaccines or therapeutics. It is also important to be able to synthesize analogs or derivatives of the structures above for example with other types of sugar and/or configuration, as e.g. mannosamine and the  $\alpha$ - or  $\beta$ -configuration to modify or to increase the biological activity of the conjugate.

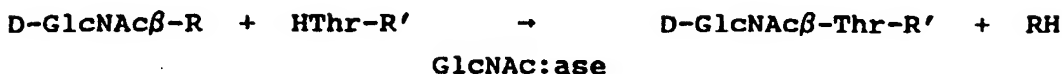
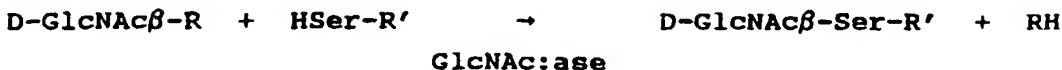
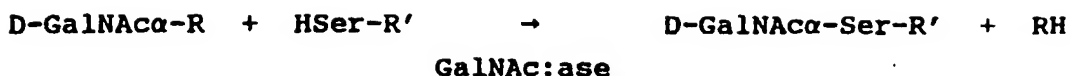
[0005] Several of these conjugates have earlier been synthesized by chemical or enzymatic methods. The disadvantages with chemical synthesis is that several reaction steps are required with extension protection group chemistry to obtain stereo- and regioselective synthesis of the conjugate and often, as a side reaction,  $\beta$ -elimination and racemization of the amino acid residue is obtained due to the weakly acidic nature of the optically active C-H linkage. The stereospecific preparation of GalNAc $\alpha$ -OSer, GalNAc $\alpha$ -OThr and derivatives of these structures is especially difficult to achieve with chemical methods.

[0006] This invention describes a novel method based on enzymatic synthesis for the preparation of such GalNAc $\alpha$ -linked compounds.

[0007] Enzymatic synthesis of glycosidic linkages can be carried out with glycosyltransferases (EC 2.4) and with glycosidases (EC 3.2) (see e.g. K. Nilsson, Trends in Biotechnology, 1988, pages 256-264, incorporated herein). Glycosyltransferases are in general not available in quantity for large-scale synthesis, have a high acceptor specificity which limits the efficiency with unnatural or modified acceptors and are dependent on nucleotide sugars as glycosyl donors. Glycosidases are abundant and have been used for synthesis of non-modified GalNAc $\alpha$ -Ser e.g. employing the substrates GalNAc and L-serine in high concentration, i.e. employing conditions for reversed hydrolysis (equilibrium) reactions (Johanson et al, Enzyme Microb. Technol., 13, 781, 1991). The yield in this reaction is however relatively low (ca. 5% according to HPLC), high concentration of purified enzyme (N-acetyl- $\alpha$ -D-galactosaminidase) is required, the reaction is relatively slow and N-glycosylation of the anomeric carbon of the GalNAc unit is a severe side reaction.

[0008] Through EP-A-0 551 107 it is known to perform glycopeptide synthesis by conjugating *inter alia* activated o-nitrophenyl- $\beta$ -D-6-O-acetyl galactosides with protected peptides, such as serine derivatives, by using  $\beta$ -galactosidase as catalyst. Similar subject matter is disclosed in EP-A-0 455 101.

[0009] One purpose of the present invention is to minimize the above mentioned problems in the chemical or enzymatic synthesis of compounds containing the GalNAc $\alpha$ -Serine and GalNAc $\alpha$ -Threonine or GlcNAc $\beta$ -Serine and GlcNAc $\beta$ -Threonine structures. The method according to the invention involves at least one reaction where an  $\alpha$ -glycoside of a saccharide which contains GalNAc at the reducing end (D-GalNAc $\alpha$ -R in the scheme below) is used as glycosyl donor and a derivative of serine or threonine (HSer-R' and HThr-R' in the scheme below) is used as acceptor in a transglycosylation reaction with an endo- or exo-N-acetyl- $\alpha$ -D-galactosaminidase (GalNAc:ase below) as the catalyst, or, alternatively, where a  $\beta$ -glycoside of a saccharide which contains GlcNAc at the reducing end (D-GlcNAc $\beta$ -R in the scheme below) is used as glycosyl donor and a derivative of serine or threonine (HSer-R' and HThr-R' in the scheme below) is used as acceptor in a transglycosylation reaction with an endo- or exo-N-acetyl- $\beta$ -D-glucosaminidase (GlcNAc:ase below) as the catalyst (scheme 1):

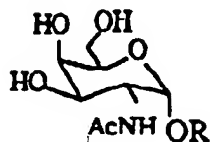


where D represents a hydroxyl group on GalNAc or GlcNAc (in the case of exo-N-acetyl- $\alpha$ -D-galactosaminidase or exo-N-acetyl- $\beta$ -D-glucosaminidase) or an inorganic or organic group, for example a saccharide group (in the latter case an endo-glycosidase is used as the catalyst); R represents a glycosidically bound aglycon (e.g., inorganic or organic group such as a glycosidically bound F-, alkyloxy- or aryloxy group) and HSer-R' and HThr-R' represent the modified serine or threonine acceptor. Examples of acceptors are L- or D-serine or L- or D-threonine containing compounds or peptides which have been modified in the N-terminal with an organic group (e.g., R-C(O) or R-O-C(O)-groups, such as for example formyl, acetyl, allyloxycarbonyl (Alloc), t-butyloxycarbonyl (Boc), benzyloxycarbonyl, fen-acetyl-, 4-methoxybenzyloxycarbonyl- (Moz-), or 9-fluorenyl methyloxycarbonyl (Fmoc) groups) and which also have been modified in the carboxyl terminal with an alkoxy or aryloxy group (e.g., methoxy, ethyloxy or phenoxy group) forming an ester group at the C-terminal group. For synthesis of protection group modified amino acids or peptides see Houben-Weyl, Bd 15/1, Kontakte 3/79, 14 and especially Synthetic Peptides, G.A. Grant, Editor, W.H. Freeman and Company, New York, 1992 (both of which are incorporated by reference in their entirety) and references therein. If a peptide derivative is acceptor in the reaction according to the invention, the size is preferably di- to penta peptide but even bigger peptide fragments can be glycosylated according to the invention. As acceptor there can also be used amino acid/peptide derivatives in the D-configuration or a mixture of D and L-configuration.

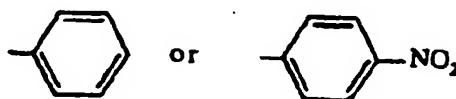
[0010] In one embodiment, the method according to the invention involves at least one reaction where an  $\alpha$ -glycoside of GalNAc (GalNAc $\alpha$ -R in the scheme below) is used as glycosyl donor and a derivative of Serine or Threonine (HSer-R<sup>1</sup>R<sup>2</sup> and HThr-R<sup>1</sup>R<sup>2</sup> in the scheme below) is used as acceptor in a transglycosylation reaction with exo-N-acetyl- $\alpha$ -D-galactosaminidase (GalNAc:ase below) as the catalyst (scheme 1):



where GalNAc $\alpha$ -R represents compounds of the type shown below:



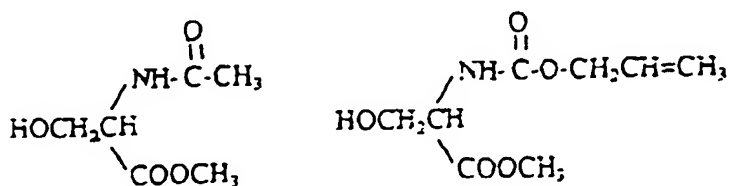
where R is an aliphatic or aromatic compound (e.g. phenyl or nitrophenyl group):



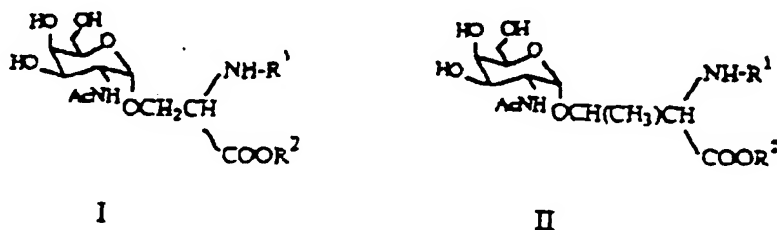
[0011] H-Ser-R<sup>1</sup>R<sup>2</sup> and H-Thr-R<sup>1</sup>R<sup>2</sup> in scheme 1 above represent molecules of the type shown below:



where R<sup>1</sup> represents a protecting group on the amino group and R<sup>2</sup> represents a protecting group on the carboxyl group. R<sup>1</sup> is preferentially selected from acyl or alkyloxy groups such as acetyl, allyloxy and butyloxy groups, respectively, and R<sup>2</sup> is preferentially selected from alkyl or aryl groups such as methyl, ethyl or phenyl groups; optionally, the carboxyl group is unprotected but preferably is protected. Typical examples of H-Ser-R<sup>1</sup>R<sup>2</sup> acceptor compounds used in the method according to the invention are thus:



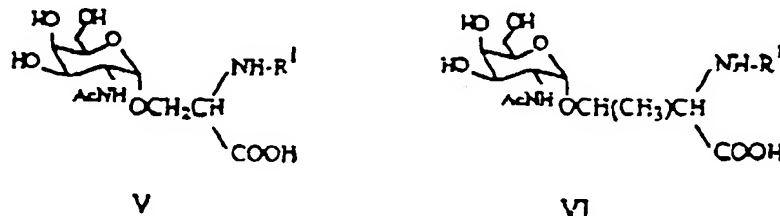
GalNAcα-Ser-R<sup>1</sup>R<sup>2</sup> and GalNAcα-Thr-R<sup>1</sup>R<sup>2</sup> compounds produced according to scheme 1 are thus:





**[0013]** The product can for example be purified by mild acidification (pH 4-5) followed by extraction with suitable organic solvent (e.g. ethyl acetate) to remove unreacted acceptor, followed by for example column chromatography or continued extraction with a less unpolar solvent to remove the product into the organic phase, or evaporation alternatively freeze drying of the water phase followed by extraction with for example methanol column chromatography of the methanol phase.

**[0015]** In a specific embodiment, the method according to the invention also involves the use of chemical or enzymatic methods for specific modification of the product with organic or inorganic groups or for the specific removal of protection groups on the amino and/or carboxyl groups. In general, protection groups are removed according to standard chemical techniques known to those skilled in the art. In addition, enzymes can be used. Thus, for example lipase or protease may be used according to the invention for removal of the R<sup>7</sup> group producing product with a free carboxyl group, e. g. reaction of compounds III and IV above with lipase gives V and VI below:



**[0017]** As an additional example, to remove the methyl ester group to obtain the product of type V, the methyl ester containing product III (350 mg) was dissolved in sodium phosphate buffer (pH 7, 50 mM, 14 ml) and 700 mg of the lipase (Boehringer, Chirazyme L-7; 2g) was added. The reaction was allowed to proceed at 45°C for 5 days and the product purified by column chromatography (Sephadex G10 and silica) which gave 164 mg of freeze-dried product).

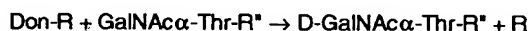
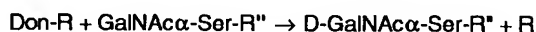
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such as in various peptide forming reactions employing peptide forming enzymes or chemical methods. When chemical methods are used for peptide formation the hydroxyl groups of the sugar may first be protected e.g. with acyl groups. See for example Houben-Weyl, Bd15/1 Kontakte 3/79, 14 and especially Synthetic Peptide, G.A. Grant, Editor, W.H. Freeman and Company, New York, 1992 for reviews on peptides and glycopeptides).

**[0019]** GalNAc $\alpha$ -Ser or GalNAc $\alpha$ -Thr containing compounds thus prepared are useful for e.g. binding to solid phases equipped with a covalently bound spacer molecule, e.g. a covalently bound alkyl amine residue such as hexylamine or covalently bound alkyl carboxyl acid such as covalently bound mercaptopropionic acid, e.g. as bound to soluble or insoluble polymers or to other surfaces, to which compounds e.g. of the type V and VI can be covalently bound with standard peptide forming reactions between the amino group of the hexylamine residue and the carboxyl group of the GalNAc $\alpha$ -Ser or GalNAc $\alpha$ -Thr compound or between the solid phase carboxyl group and the amino group of said compounds. Alternatively, the GalNAc $\alpha$ -Ser or the GalNAc $\alpha$ -Thr compound is first modified in solution with the spacer molecule and the resulting spacer modified compound is then used for binding to the solid phase (or alternatively to a protein, peptide, lipid, polyethylene glycol or other organic molecule of interest for the specific application).

**[0020]** The solid phase thus prepared containing bound GalNAc $\alpha$ -Ser or GalNAc $\alpha$ -Thr containing residues can be used for analytical, down stream processing (affinity chromatography) or for (solid phase) synthetic purposes. Example of solid phases are those based on synthetic or naturally occurring polymers, such as polystyrene, polyacrylamine, copolymers, etc, cellulose, agarose, etc. commonly used in analytical or down stream processing applications, metal coated surfaces, such as gold or silver coated materials and colloidal gold particles. Methods for binding of molecules to such surfaces are well documented in the literature, (see e.g. Method in Enzymology, vol. 44, 104, 134-137 and in WO-A-9.424.561 (PCT/SE94/00343)) and are straightforward to apply in analytical, down stream processing or solid phase synthetic applications.

**[0021]** The GalNAc $\alpha$ -Ser or GalNAc $\alpha$ -Thr containing compounds obtained in the scheme 1 and/or after immobilization with the methods above are useful e.g. as acceptors in enzymatic reactions employing either glycosyltransferases or glycosidases as catalysts. Thus, by using a glycosidase specific for the glycosyl donor Don-R (where Don symbolizes a sugar unit and R symbolizes an aglycon such as a nitrophenyl group, which is bound in  $\alpha$ - or  $\beta$ - configuration to the sugar group) one can obtain the product Don-GalNAc $\alpha$ -Ser-R\* or Don-GalNAc $\alpha$ -Thr-R\* (where R\* symbolize either -H, i.e. no modification on the serine or threonine residue, or a modification by an amino acid, peptide or other organic group, on at least one of the amino or carboxyl groups):



**[0022]** Don above may be selected from the group consisting of compounds containing at least one L-fucosyl, D-glucosyl-, D-galatosyl-, D-mannosyl, D-xylosyl, N-acetyl-D-glucosaminyl, N-acetyl-D-galactosylaminyl or sialyl group. The glycosidase may be selected from the group of exo- or endoglycosidases belonging to the EC 3.2. class of hydrolases.

**[0023]** An example is the use of  $\beta$ -galactosidase preparation (obtained from e.g. bovine testes) as catalyst and lactose or Gal $\beta$ -PNP (PNP=p-nitrophenyl) as glycosyl donor to prepare Gal $\beta$ 1-3GalNAc $\alpha$ -Ser-R\* or Gal $\beta$ 1-3GalNAc $\alpha$ -Thr-R\*, by carrying out the reaction in e.g. sodium acetate or sodium phosphate buffer with or without organic solvents, and at room temperature or at elevated temperature.

**[0024]** With glycosyltransferases a nucleotide sugar, Don-N, is used as donor and GalNAc $\alpha$ -Ser-R\* or GalNAc $\alpha$ -Thr-R\* as acceptor. An example is the use of sialyltransferase to produce NeuAca2-6GalNAc $\alpha$ -Ser-R\* or NeuAca2-6GalNAc $\alpha$ -Thr-R\* employing CMP-NeuAc as donor. Glycosyltransferases are also of interest for use with solid phase bound GalNAc $\alpha$ -Ser-R\* or GalNAc $\alpha$ -Thr-R\*.

**[0025]** The above types of disaccharide products can be applied for analytical down-stream processing, or (solid phase) chemical or enzymatic synthetic purposes as described above.

**[0026]** The products are also of interest for therapeutic applications, for modification of organic compounds of therapeutic interest, or of interest as food or cosmeceutical product additives to obtain products with novel properties.

**[0027]** Previous preparative enzymatic synthesis of GalNAc-Ser or GalNAc-Thr relies on large quantities of expensive GalNAc as glycosyl donor in comparably slow equilibrium reactions affording low yields, requiring high concentrations of purified enzyme, and which give side products as N-glycosylation of GalNAc which is difficult to separate from the O-glycosylated GalNAc-Serine or Threonine products. With the method according to the present invention, higher yields (in the range 10-50% or higher) are obtained, much less enzyme is required due to more reactive donor substrate, the enzyme does not need extensive purification before use in the synthesis according to the invention and N-glycosylation is avoided.

[0028] The yield of product is often in the range of 10-50% as calculated on the donor. Depending on the amount of enzyme activity added (Units of enzyme), the reaction can be carried out for e.g. 15 minutes up to 24 hours or more. In general, the reaction time is determined by the reaction rate and is stopped when the donor is consumed (if this is used as the limiting substrate) or preferably when the maximum amount of product has been formed (as determined e.g. by HPLC).

[0029] Non-limiting examples of reaction according to scheme 1 above is given below.

## EXAMPLES

[0030] Compounds of the type III, IV, and V were prepared by reaction of GalNAc $\alpha$ -PNP (typically added to a concentration in the range 50-150mM) with either of Ac-N-L-Ser-OMe or Alloc-N-L-Ser-OMe, respectively, as acceptors (in a typical concentration in the range 150mM-2M) suspended in sodium acetate buffer, pH 4.4, and enzyme was added (enzyme used in crude form as obtained from *Aspergillus oryzae* by ammonium sulphate fractionation of a commercial (Sigma, St. Louis, MO)  $\beta$ -galactosidase preparation (1: 50% ammonium sulphate precipitation; 2: 80% ammonium sulphate precipitation followed by dialysis and freeze-drying). Typically the reaction was carried out at a given temperature in the range room temperature to 45°C, until the main part of the glycosyl donor had reacted. The product (III and IV, respectively) was purified by separation on a column packed with e.g. Sephadex G10 (Pharmacia, Uppsala, Sweden; water as eluent), after which product containing fractions were freeze-dried. To remove the methyl ester group the product treated with lipase (e.g. Boehringer, Chirazyme®L-7) which gave product of type V after separation on e.g. ion-exchanger (Q-Sepharose, Pharmacia, Uppsala, Sweden). Compounds of type V and VI were prepared similarly employing the corresponding threonine acceptors.

[0031] GalNAc $\alpha$ -PNP (170 mM) and N-Alloc-L-Ser-OMe (0.9 M) suspended in sodium acetate buffer (pH 4.4) were reacted at 45°C for 4 hours with 30 mg (per 0.5 ml reaction volume) of freeze-dried GalNAc $\alpha$ -ase as catalyst (prepared as described above). At this time the reaction was stopped indicating formation of 40 mM product (HPLC; ca 23% molar yield as calculated on reacted donor).

[0032] GalNAc $\alpha$ -PNP (170 mM) and N-acetyl-L-Ser-OMe (2 M) suspended in sodium acetate buffer (pH 4.4) were reacted as described above at 45°C with freeze-dried GalNAc $\alpha$ -ase as catalyst (prepared as described above) until ca 70 mM product was obtained (HPLC; ca 40% molar yield as calculated on reacted donor).

[0033] GalNAc $\alpha$ -PNP (170 mM) and N-acetyl-L-Thr-OMe (0.9 M) suspended in sodium acetate buffer (pH 4.4) were reacted as described above at 45°C with freeze-dried GalNAc $\alpha$ -ase as catalyst (prepared as described above) until ca 49 mM product was obtained (HPLC; ca 29% molar yield as calculated on reacted donor).

## Claims

1. Method for synthesis of GalNAc $\alpha$ -serine or GalNAc $\alpha$ -threonine containing compounds, comprising at least one reaction where an  $\alpha$ -saccharide or  $\alpha$ -glycoside of GalNAc is used as glycosyl donor and a derivative of serine or threonine is used as acceptor in a transglycosylation reaction with N-acetyl- $\alpha$ -D-galactosaminidase as the catalyst, wherein said acceptor has been modified in both its N-terminal  $\alpha$ -amino group and in its C-terminal carboxyl group.
2. A method for the synthesis of a GalNAc $\alpha$ -serine or GalNAc $\alpha$ -threonine containing compound, said method comprising reacting (a) a glycosyl donor which is  $\alpha$ -saccharide or  $\alpha$ -glycoside of GalNAc, (b) an acceptor which is serine or threonine or peptide containing serine or threonine wherein said serine or threonine contains a protection group in both its N-terminal  $\alpha$ -amino group and in its C-terminal carboxyl group, and (c) an enzyme which is N-acetyl- $\alpha$ -D-galactosaminidase.
3. The method according to claim 2, further comprising isolating the product from the reaction mixture.
4. A GalNAc $\alpha$ -serine or GalNAc $\alpha$ -threonine containing compound produced by the method according to any one of claims 1-2.
5. The method according to claim 2, wherein said protection group in said N-terminal  $\alpha$ -amino group is an acyl or alkyloxy group and wherein said protection in said C-terminal carboxyl group is an alkyl or aryl group.
6. The method according to claim 2, further comprising subsequently removing said protection group in said N-terminal  $\alpha$ -amino group and/or said protection in said C-terminal carboxyl group.
7. The method according to claims 2 or 6, further comprising using said GalNAc $\alpha$ -serine or GalNAc $\alpha$ -threonine con-

taining compound as an acceptor in a reaction with a glycosyltransferase or glycosidase and glycosyl donor Don-R where Don symbolizes a sugar unit and R symbolizes an aglycon which is bound in  $\alpha$ - or  $\beta$ - configuration to said sugar group.

- 5 8. Method for synthesis of GalNAc $\alpha$ -serine or GalNAc $\alpha$ -threonine containing compounds, comprising at least one reaction where an  $\alpha$ -saccharide or  $\alpha$ -glycoside of GalNAc or  $\beta$ -saccharide or  $\alpha$ -glycoside of GlcNAc is used as glycosyl donor and a derivative of serine or threonine is used as acceptor in a transglycosylation reaction with an endo- or exo-N-acetyl- $\alpha$ -D-galactosaminidase or an endo- or exo-N-acetyl- $\beta$ -D-glucosaminidase as the catalyst, wherein said acceptor has been modified in both its N-terminal  $\alpha$ -amino group and in its C-terminal carboxyl group.
- 10 9. A method for the synthesis of a GalNAc $\alpha$ -serine or GalNAc $\alpha$ -threonine containing compound, said method comprising reacting (a) a glycosyl donor which is  $\alpha$ -saccharide or  $\alpha$ -glycoside of GalNAc or  $\beta$ -saccharide or  $\alpha$ -glycoside of GlcNAc, (b) an acceptor which is serine or threonine or peptide containing serine or threonine wherein said serine or threonine contains a protection group in both its N-terminal  $\alpha$ -amino group and in its C-terminal carboxyl group, and (c) an enzyme which an endo- or exo-N-acetyl- $\alpha$ -D-galactosaminidase or an endo- or exo-N-acetyl- $\beta$ -D-glucosaminidase.
- 15 10. The method according to claim 9, further comprising isolating the product from the reaction mixture.
- 20 11. A GalNAc $\alpha$ -serine or GalNAc $\alpha$ -threonine or GlcNAc $\beta$ -serine or GlcNAc $\beta$ -threonine containing compound produced by the method according to any one of claims 8-9.

#### Patentansprüche

- 25 1. Verfahren zur Synthese von GalNAc $\alpha$ -Serin oder GalNAc $\alpha$ -Threonin enthaltenden Verbindungen, umfassend mindestens eine Reaktion, bei der ein  $\alpha$ -Saccharid oder  $\alpha$ -Glycosid von GalNAc als Glycosyldonor verwendet wird und ein Derivat von Serin oder Threonin als Akzeptor in einer Transglycosylierungsreaktion mit N-Acetyl- $\alpha$ -D-Galactosaminidase als Katalysator verwendet wird, wobei der Akzeptor sowohl an seiner N-terminalen  $\alpha$ -Aminogruppe als auch an seiner C-terminalen Carboxylgruppe modifiziert worden ist.
- 30 2. Verfahren zur Synthese einer GalNAc $\alpha$ -Serin oder GalNAc $\alpha$ -Threonin enthaltenden Verbindung, wobei das Verfahren das Umsetzen von (a) einem Glycosyldonor, welcher ein  $\alpha$ -Saccharid oder  $\alpha$ -Glycosid von GalNAc ist, (b) einem Akzeptor, welcher Serin oder Threonin oder ein Peptid ist, das Serin oder Threonin enthält, wobei das Serin oder Threonin eine Schutzgruppe sowohl an seiner N-terminalen  $\alpha$ -Aminogruppe als auch an seiner C-terminalen Carboxylgruppe enthält, und (c) einem Enzym, welches N-Acetyl- $\alpha$ -D-Galactosaminidase ist, umfaßt.
- 35 3. Verfahren nach Anspruch 2, das außerdem das Isolieren des Produkts aus dem Reaktionsgemisch umfaßt.
- 40 4. GalNAc $\alpha$ -Serin oder GalNAc $\alpha$ -Threonin enthaltende Verbindung, die durch das Verfahren nach einem der Ansprüche 1 - 2 hergestellt ist.
- 45 5. Verfahren nach Anspruch 2, worin die Schutzgruppe an der N-terminalen  $\alpha$ -Aminogruppe eine Acyl- oder Alkyl- oder Arylgruppe ist und worin die Schutzgruppe an der C-terminalen Carboxylgruppe eine Alkyl- oder Arylgruppe ist.
- 50 6. Verfahren nach Anspruch 2, das außerdem das anschließende Entfernen der Schutzgruppe an der N-terminalen  $\alpha$ -Aminogruppe und/oder der Schutzgruppe an der C-terminalen Carboxylgruppe umfaßt.
- 55 7. Verfahren nach den Ansprüchen 2 oder 6, das außerdem das Verwenden der GalNAc $\alpha$ -Serin oder GalNAc $\alpha$ -Threonin enthaltenden Verbindung als Akzeptor in einer Reaktion mit einer Glycosyltransferase oder Glycosidase und dem Glycosyldonor Don-R umfaßt, wobei Don eine Zuckereinheit bedeutet und R ein Aglycon bedeutet, welches in  $\alpha$ - oder  $\beta$ -Konfiguration an die Zuckergruppe gebunden ist.
8. Verfahren zur Synthese von GalNAc $\alpha$ -Serin oder GalNAc $\alpha$ -Threonin enthaltenden Verbindungen, umfassend mindestens eine Reaktion, bei der ein  $\alpha$ -Saccharid oder  $\alpha$ -Glycosid von GalNAc oder  $\beta$ -Saccharid oder  $\alpha$ -Glycosid von GlcNAc als Glycosyldonor verwendet wird und ein Derivat von Serin oder Threonin als Akzeptor in einer Transglycosylierungsreaktion mit einer endo- oder exo-N-Acetyl- $\alpha$ -D-Galactosaminidase oder einer endo- oder exo-N-Acetyl- $\beta$ -D-Glucosaminidase als Katalysator verwendet wird, wobei der Akzeptor sowohl an seiner N-ter-



minalen  $\alpha$ -Aminogruppe als auch an seiner C-terminalen Carboxylgruppe modifiziert worden ist.

9. Verfahren zur Synthese einer GalNAc $\alpha$ -Serin oder GalNAc $\alpha$ -Threonin enthaltenden Verbindung, wobei das Verfahren das Umsetzen von (a) einem Glycosyldonor, welcher ein  $\alpha$ -Saccharid oder  $\alpha$ -Glycosid von GalNAc oder  $\beta$ -Saccharid oder  $\alpha$ -Glycosid von GlcNAc ist, (b) einem Akzeptor, welcher Serin oder Threonin oder ein Peptid ist, das Serin oder Threonin enthält, wobei das Serin oder Threonin eine Schutzgruppe sowohl an seiner N-terminalen  $\alpha$ -Aminogruppe als auch an seiner C-terminalen Carboxylgruppe enthält, und (c) einem Enzym, welches eine endo- oder exo-N-Acetyl- $\alpha$ -D-Galactosaminidase oder eine endo- oder exo-N-Acetyl- $\beta$ -D-Glucosaminidase ist, umfaßt.
10. Verfahren nach Anspruch 9, das außerdem das Isolieren des Produkts aus dem Reaktionsgemisch umfaßt.
11. GalNAc $\alpha$ -Serin oder GalNAc $\alpha$ -Threonin oder GlcNAc $\beta$ -Serin oder GlcNAc $\beta$ -Threonin enthaltende Verbindung, die durch das Verfahren nach einem der Ansprüche 8 - 9 hergestellt ist.

#### Revendications

1. Procédé de synthèse de composés contenant de la GalNAc $\alpha$ -sérine ou de la GalNAc $\alpha$ -thréonine comprenant au moins une réaction dans laquelle un  $\alpha$ -saccharide ou un  $\alpha$ -glycoside de GalNAc est utilisé comme donneur de glycosyle et un dérivé de la sérine ou de la thréonine est utilisé comme accepteur dans une réaction de transglycosylation avec la N-acétyl- $\alpha$ -D-galactosaminidase comme catalyseur, où ledit accepteur a été modifié à la fois dans son groupe  $\alpha$ -amino N-terminal et dans son groupe carboxyle C-terminal.
2. Procédé de synthèse d'un composé contenant de la GalNAc $\alpha$ -sérine ou de la GalNAc $\alpha$ -thréonine, ledit procédé comprenant la réaction (a) d'un donneur de glycosyle qui est un  $\alpha$ -saccharide ou un  $\alpha$ -glycoside de GalNAc, (b) d'un accepteur qui est la sérine ou la thréonine ou un peptide contenant de la sérine ou de la thréonine, où ladite sérine ou thréonine contient un groupe protecteur à la fois dans son groupe  $\alpha$ -amino N-terminal et dans son groupe carboxyle C-terminal, et (c) d'une enzyme qui est la N-acétyl- $\alpha$ -D-galactosaminidase.
3. Procédé selon la revendication 2 comprenant en outre l'isolement du produit à partir du mélange réactionnel.
4. Composé contenant de la GalNAc $\alpha$ -sérine ou de la GalNAc $\alpha$ -thréonine produit par le procédé selon l'une quelconque des revendications 1 et 2.
5. Procédé selon la revendication 2 où ledit groupe protecteur dans ledit groupe  $\alpha$ -amino N-terminal est un groupe acyle ou alkyloxy et où ladite protection dans ledit groupe carboxyle C-terminal est un groupe alkyle ou aryle.
6. Procédé selon la revendication 2 comprenant en outre le retrait subséquent dudit groupe protecteur dans ledit groupe  $\alpha$ -amino N-terminal et/ou de ladite protection dans ledit groupe carboxyle C-terminal.
7. Procédé selon la revendication 2 ou 6 comprenant en outre l'utilisation dudit composé contenant de la GalNAc $\alpha$ -sérine ou de la GalNAc $\alpha$ -thréonine comme accepteur dans une réaction avec une glycosyltransférase ou une glycosidase et un donneur de glycosyle Don-R où Don symbolise une unité glucidique et R symbolise un aglycone qui est lié audit groupe glucidique dans la configuration  $\alpha$  ou  $\beta$ .
8. Procédé de synthèse de composés contenant de la GalNAc $\alpha$ -sérine ou de la GalNAc $\alpha$ -thréonine comprenant au moins une réaction dans laquelle un  $\alpha$ -saccharide ou un  $\alpha$ -glycoside de GalNAc ou un  $\beta$ -saccharide ou un  $\alpha$ -glycoside de GlcNAc est utilisé comme donneur de glycosyle et un dérivé de la sérine ou de la thréonine est utilisé comme accepteur dans une réaction de transglycosylation avec une endo- ou exo-N-acétyl- $\alpha$ -D-galactosaminidase ou une endo- ou exo-N-acétyl- $\beta$ -D-glucosaminidase comme catalyseur, où ledit accepteur a été modifié à la fois dans son groupe  $\alpha$ -amino N-terminal et dans son groupe carboxyle C-terminal.
9. Procédé de synthèse d'un composé contenant de la GalNAc $\alpha$ -sérine ou de la GalNAc $\alpha$ -thréonine, ledit procédé comprenant la réaction (a) d'un donneur de glycosyle qui est un  $\alpha$ -saccharide ou un  $\alpha$ -glycoside de GalNAc ou un  $\beta$ -saccharide ou un  $\alpha$ -glycoside de GlcNAc, (b) d'un accepteur qui est la sérine ou la thréonine ou un peptide contenant de la sérine ou de la thréonine, où ladite sérine ou thréonine contient un groupe protecteur à la fois dans son groupe  $\alpha$ -amino N-terminal et dans son groupe carboxyle C-terminal, et (c) d'une enzyme qui est une

endo- ou exo-N-acétyl- $\alpha$ -D-galactosaminidase ou une endo- ou exo-N-acétyl- $\beta$ -D-glucosaminidase.

10. Procédé selon la revendication 9 comprenant en outre l'isolement du produit à partir du mélange réactionnel.

5 11. Composé contenant de la GalNAc $\alpha$ -sérine ou de la GalNAc $\alpha$ -thréonine ou de la GlcNAc $\beta$ -sérine ou de la GlcNAc $\beta$ -thréonine produit par le procédé selon l'une quelconque des revendications 8 et 9.

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